COYOTE-HOLE PRIMARY BLASTING, DRESSER TRAP ROCK CO., DRESSER, WIS.

By L. G. Marshall

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Information Circular 7913

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COYOTE-HOLE PRIMARY BLASTING, DRESSER TRAP ROCK CO., DRESSER, WIS.[1]

by

L. G. Marshall[2]

INTRODUCTION

This report, describing the mining method of the Dresser Trap Rock Co., Dresser, Wis., is one of a series published by the Bureau of Mines on mining methods, performance, and costs at mining operations throughout the United States.

SUMMARY

Dresser, in Polk County, is 3 miles south of St. Croix Falls, Wis. Company operations are about 1 mile north of the townsite. The mine has been in operation since 1914 and under the present ownership since 1949.

The formation being exploited is an altered basalt at the southwestern extremity of a belt of igneous rocks of the Keweenawan era that trends northeast to Lake Superior. The deposit is highly jointed and faulted. Because of the irregular open jointing, the deposit, as exposed in the quarry workings, appears as unconsolidated blocks, slabs, and wedges, a physical characteristic desirable for the type of fragmentation used.

Overburden ranges in depth from 0 to 3 feet. Stripping is done both under contract and by the company. Bulldozers are used to push the overburden into windrows for loading into trucks by small diesel shovels.

The quarry face, at the site of the present operations, ranges from 65 to 113 feet in height. The accepted means of blasting is by the coyote-hole method. On April 23, 1958, two unrelated coyote-hole blasts were set off. One blast of 15.40 tons of explosives, loaded in 13 pockets in 4 crosscuts serviced by a 67-foot adit, dislodged an estimated 209,000 tons of rock. The powder factor was 0.147 pound per ton. The other blast of 4.35 tons of explosives, loaded in 10 pockets in 4 crosscuts, dislodged an estimated 66,000 tons. The powder factor was 0.132 pound per ton of rock. Underground adits and crosscuts had an average cross section of 4 by 4 feet and totaled 501

1/ Work on manuscript completed November 1958.

2/ Mine examination and exploration engineer, Bureau of Mines, Region V, Minneapolis, Minn.

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linear feet. The average advance per round was 2 feet. The total number of man-hours expended was 5,653.

Steam shovels and locomotives manufactured during the period 1914-24 are used in loading and transporting the stone to the mill for processing.

ACKNOWLEDGMENTS

Sincere appreciation is extended to Carl R. Thye, president, Dresser Trap Rock Co., for permission to publish this paper, also to Jules Larson, retired vice president and superintendent, and M. G. Astleford, general manager, for their many courtesies and cooperation in furnishing a large part of the information in this circular.

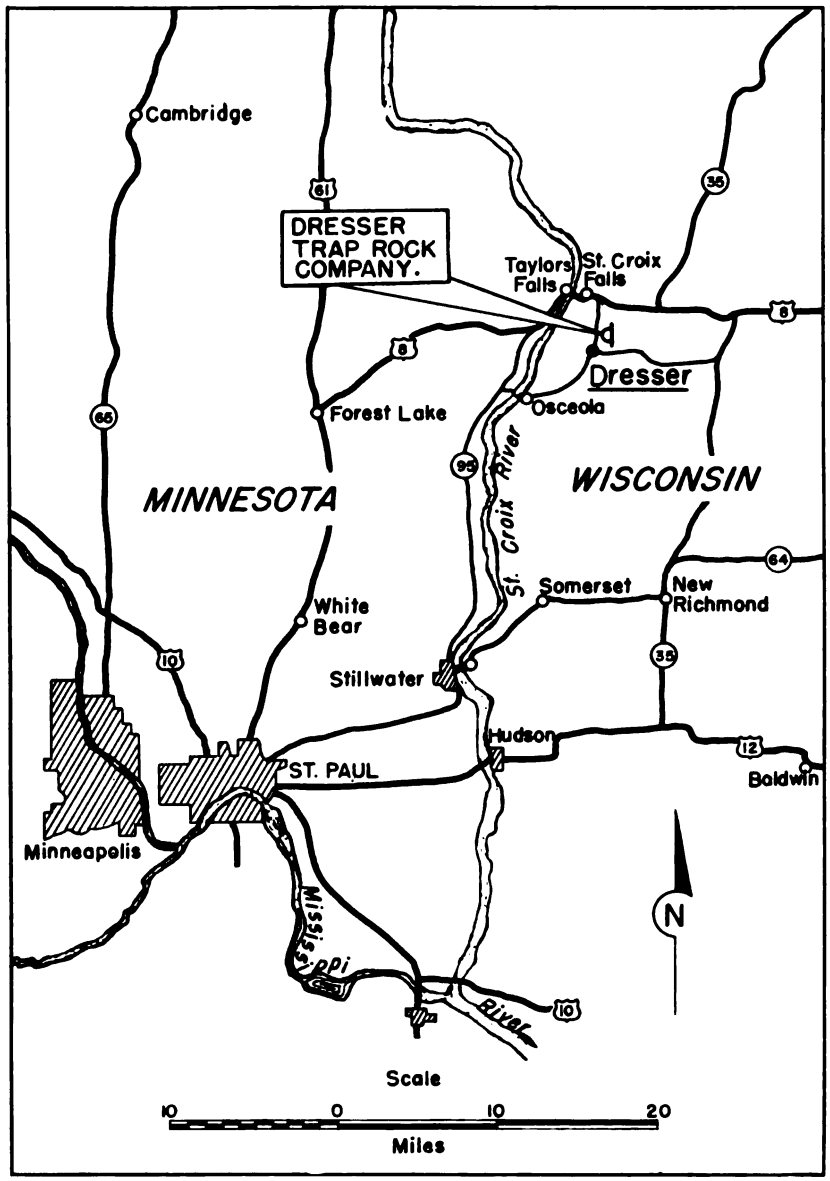

FIGURE 1. - Location Map, Dresser Trap Rock Co., Dresser, Wis.

HISTORY

Exploitation of the traprock deposits in the vicinity of Taylors Falls, Minn., was begun by a local group of farmers. Because of financial and operational difficulties, in 1913 a 50-percent interest was offered for purchase to John Wunder, a construction contractor of Minneapolis, Minn. The original operations were abandoned in 1914 and activities transferred to the present site, about 1 mile north of Dresser, Wis. (fig. 1). Under the direction of Wunder, the quarry was developed, and the present plant was constructed (fig. 2). Some equipment purchased at that time is still in use.

After Wunder's death in 1931, operations were continued by his heirs. In 1949 the corporation was purchased by a group of Dresser and St. Croix Falls businessmen. Operations have been conducted continuously since that date under the name of Dresser Trap Rock Co.

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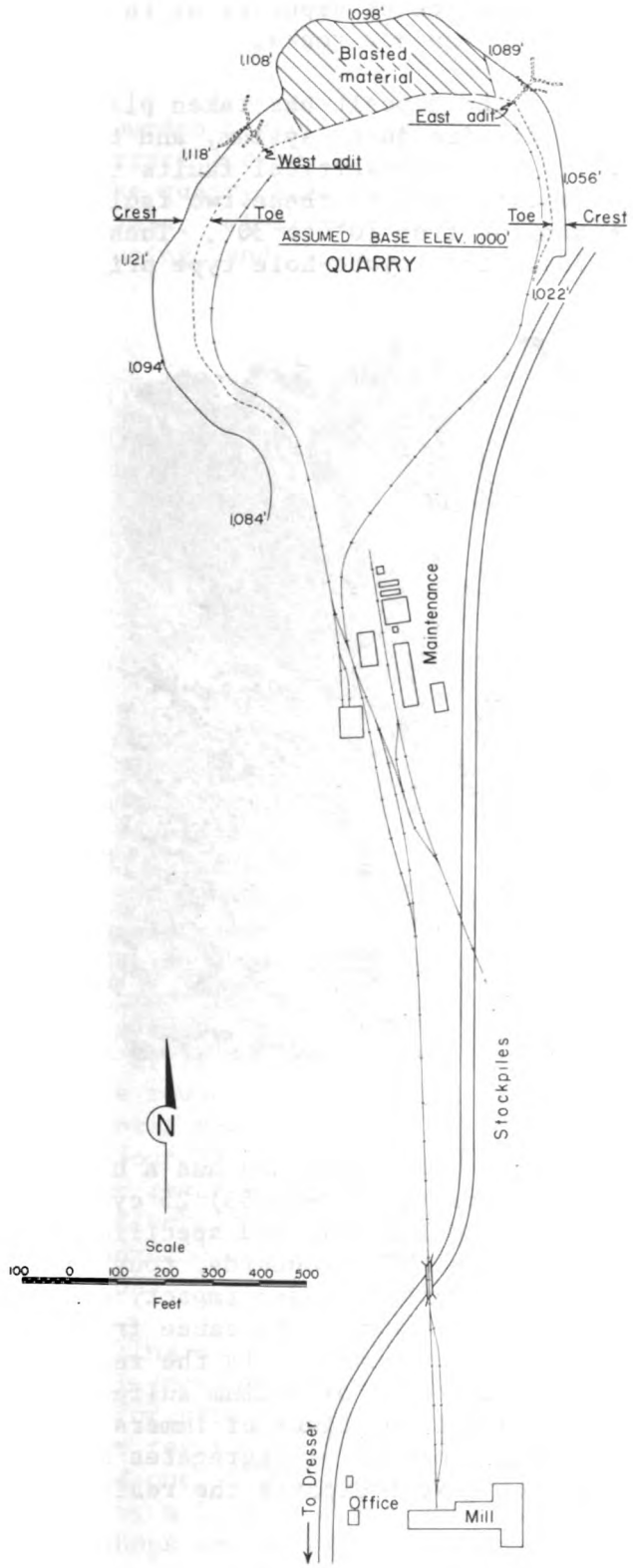

FIGURE 2. - Plant and Quarry.

The processed stone is used as road surfacing, bituminous aggregate, railroad ballast, concrete aggregate, custom aggregate for heavy-duty floors, and filter stone for sewage-disposal plants. The Perfect Seal Manufacturing Co., Walworth, Wis., used this stone in manufacturing rock wool until the plant was destroyed by fire in late 1957.

Yearly production ranges between 125,000 and 150,000 short tons of processed stone. Nearly 47 percent is aggregate used for road surfacing and concrete, 50 percent is used for railroad ballast, and 3 percent is used for filter rock. Reportedly, experiments are being conducted at foundries using fine material from the mill in the cleaning of castings as a possible replacement of aluminum oxide.

THE DEPOSIT

Dresser is at the southwestern limit of a belt of igneous rocks of the Keweenawan era, trending northeast-southwest through the northern part of Wisconsin to Lake Superior. These Precambrian rocks consist mainly of gabbros and basic lava flows, with both basic and acid intrusives.

In the vicinity of Dresser the deposit has undergone considerable hydrothermal or deuteric alteration. As a result of this metamorphism, positive classification is difficult; however, the rock has been designated as either an altered gabbro or an altered basalt, the latter being most commonly used.

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The term "traprock" is sometimes used in reference to deposits of this type and is a general term for dark, fine-grained, igneous rocks.

Extensive, irregular, open jointing of the deposit has taken place (figs. 3 and 6). There is no appearance of any definite joint system, and the strike and dip of the joints range through 180°. Two near-vertical faults transverse the quarry east-west and north-south. Associated with these two faults are several flat-dipping faults, with dips ranging from 10° to 30°. These physical characteristics of the deposit are ideal for coyote-hole type primary blasting.

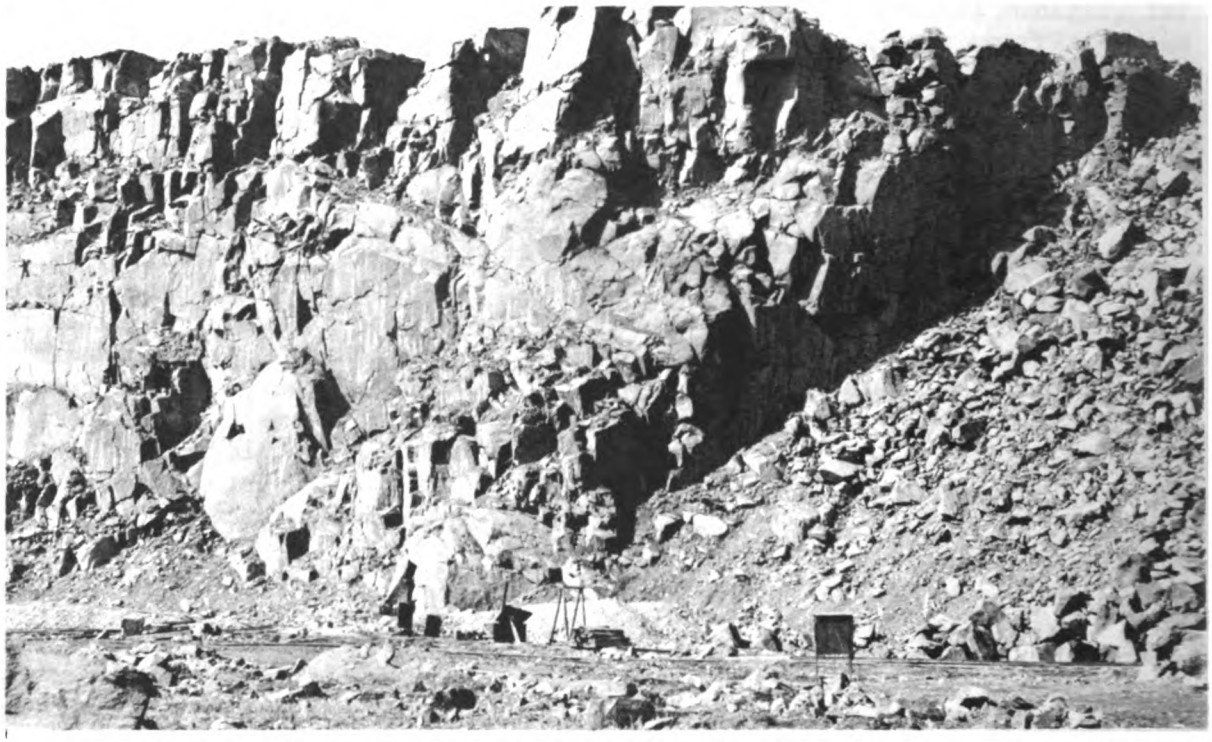

FIGURE 3. - Quarry Face Showing Jointing.

The stone ranges from dark green to black and reportedly has a hardness of 3.2, toughness (ASTM D-3-18) of 19, soundness (ASTM C-88-55) 25 cycles, 9-percent loss by Los Angeles Rattler test (ASTM C-131-55), and specific gravity of 3.00; and it fuses at 2,206° F. According to ASTM standards, toughness, as applied to rock, is the resistance offered to fracture under impact, expressed as the final height of blow required of a standard hammer to cause fracture of a cylindrical test specimen of given dimensions. Soundness is the resistance to disintegration by immersion in saturated solutions of sodium sulfate or magnesium sulfate, the cycles referring to the number of times of immersion. It furnishes information helpful in judging the soundness of aggregates subject to weathering action. The California Rattler test indicates the resistance of an aggregate to abrasive action.

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MINING

Stripping

Overburden ranges in depth from 0 to 3 feet. Stripping is done both under contract and by the company. The overburden is pushed back from the face of the quarry into windrows by bulldozers, and loaded into trucks by power shovels. Final cleanup of the eroded surface is done by company employees, using hand shovels.

Blasting

Before 1930 three attempts were made to drill blast holes with churn drills. In all, eight holes were drilled; only one bottomed at the quarry-floor elevation. Principal difficulties were deviation and caving of the holes. Since that time no attempts have been made with that or other types of drilling equipment.

Coyote-hole blasting has become the accepted method of primary fragmentation. The open jointing and fracturing have produced the effect of a deposit of unconsolidated blocks, slabs, and wedges, favorable to this type of blasting.

The April 23, 1958, blast consisted of two unrelated coyote holes, whose portals were 540 feet apart. Between the portals was 370 feet of previously blasted rock (fig. 4). The west workings consisted of 67 feet of adit and 205 feet of crosscuts. The east adit penetrated the formation for 67 feet and serviced 162 feet of crosscuts. Development was completed March 25 and required 4,394 man-hours. Loading and stemming were begun April 17, completed April 22, and required 1,260 man-hours. During this period, 19.75 tons of explosives and about 500 tons of stemming were placed in the coyote holes.

The average cross section of the underground openings was 4 by 4 feet. A typical drill round (fig. 5) consisted of five holes. One hole, in the center of the round, was drilled to a depth of 30 inches. The other four were collared near the center of the round and angled to the four corners of the drift. About 25 1-1/2- by 8-inch sticks of 60-percent gelatin dynamite were loaded per round and detonated by No. 6 electric blasting caps connected in series. Electric power for blasting was taken from the 220-volt quarryline. Average advance per round was 2 feet. The powder factor was 3.611 pounds per ton of stone.

Drilling was done with Ingersoll-Rand manual feed drifters mounted on horizontal jackscrew bars. The drill steel used was 1-1/2-inch round steel threaded for detachable bits. Timken 1-3/4-inch-gage bits were discarded when used after regrinding to 1-1/4 inches. Drilling in each coyote hole was done on a round-out, round-in, two-man, 10-hour shift basis. Compressed air was supplied by a 1,200-c.f.m., Ingersoll-Rand, stationary compressor at the maintenance shops and a portable, diesel-powered Gardner-Denver compressor of 600-c.f.m. capacity. Air was piped to the quarry face in an 1,100-foot, 6-inch line that was reduced to 1 inch in the adits. Water for drilling was supplied

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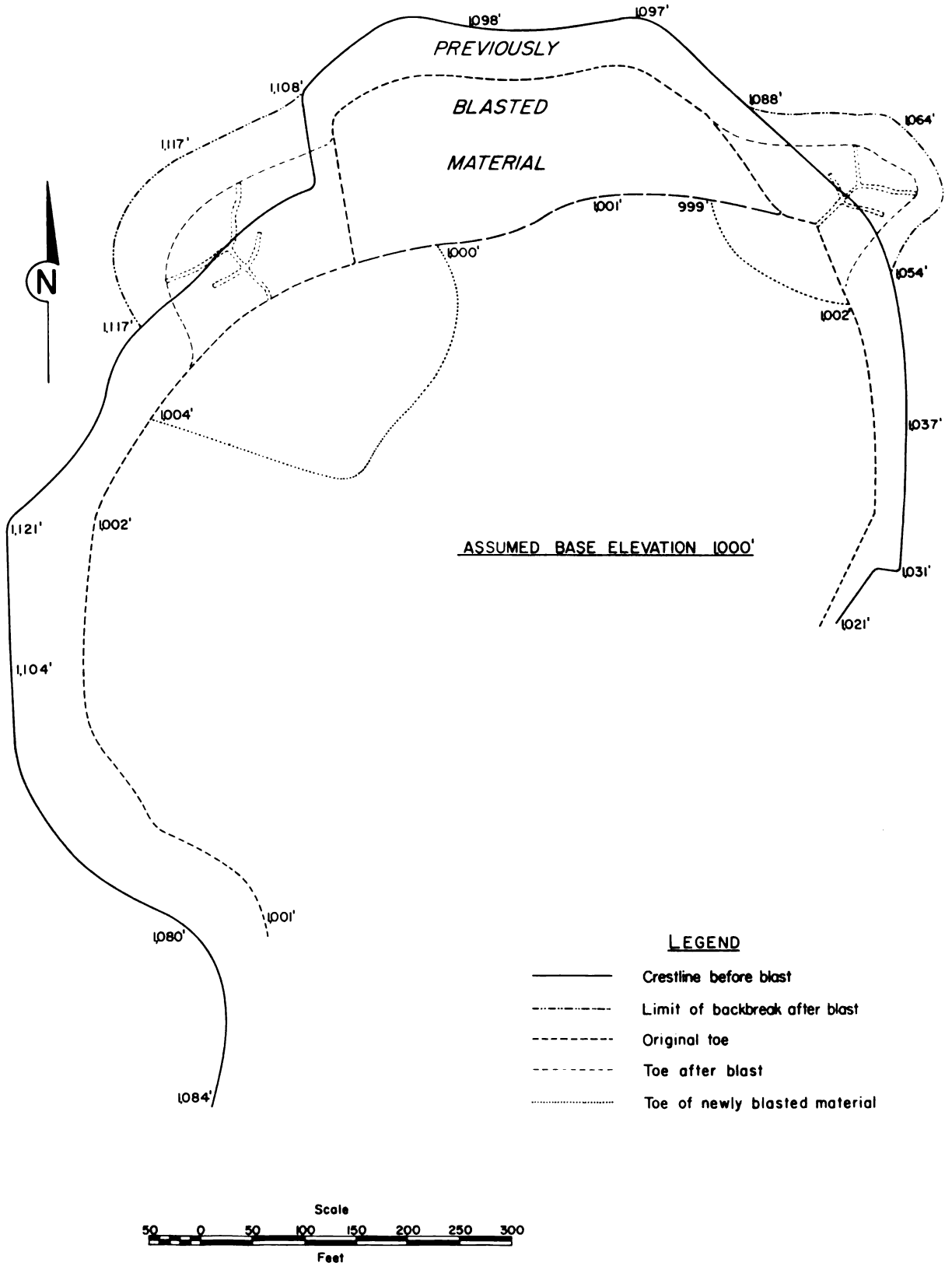

FIGURE 4. - Plan of Quarry.

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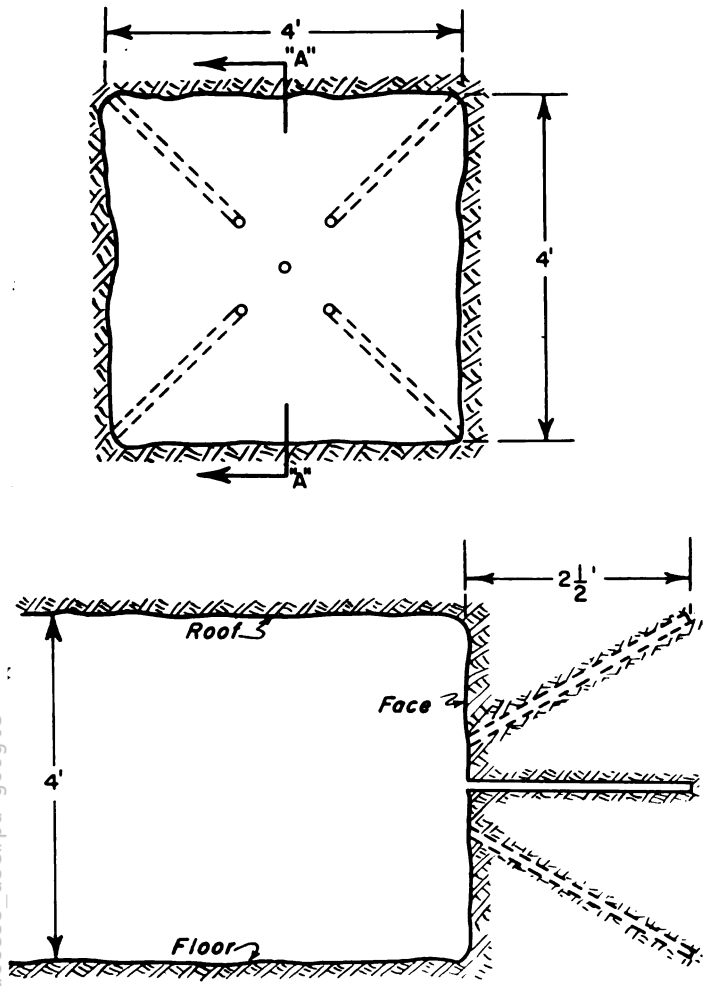

Section "A-A"
Through center of tunnel

FIGURE 5. - Coyote Hole Drill Round.

from 10-gallon pressure tanks at the portals. Throughout the winter months water was heated over an open fire in 50-gallon drums near the portal and transferred to the pressure tanks when needed.

Broken stone was mucked off the rough with short-handled, round-point shovels into cars of about 150-pound capacity (fig. 6). Cars were hand-trammed to the dump on a 9-inch-gage track. The maximum tram distance in the west workings to the dump was 180 feet and in the east workings, 155 feet.

The west adit was driven 67 feet (fig. 7). Crosscuts were driven easterly and westerly at 38 feet for lengths of 34 and 35 feet and at the end of the adit for 66 and 70 feet. Crosscut 1W was loaded with 2,200 pounds of Hercules Tritex-W.R., a nitro-carbo-nitrate explosive, in 8- by 27-1/2-inch sticks, each weighing 50 pounds. The explosive was loaded in three pockets; each pocket primed by two 8- by 18-1/2-inch, 50-pound sticks of Hercules Gelamite-D, a 60-percent semigel dynamite, making a total charge of 2,500 pounds. Crosscut 1E was loaded with 2,700 pounds of Tritex-W.R. in three pockets, each primed with two sticks of Gelamite-D. A line of Primacord was laid on each side of the crosscuts and was extended as loading and stemming progressed. These lines were crosstied at 10-foot intervals, and all connections were taped. A line of Primacord was threaded through each primer stick and connected to both trunklines.

Crosscut 2W extending 70 feet from the adit was loaded with 11,000 pounds of Tritex-W.R. in four pockets primed by 600 pounds of Gelamite-D. Crosscut 2E was loaded with 13,000 pounds of Tritex-W.R. in three pockets primed with 700 pounds of Gelamite-D. The double line of Primacord was laid as in the other crosscuts and extended outward in the adit because this opening was stemmed.

A light aluminum roller conveyor, assembled in 10-foot sections, transported the dynamite and stemming into the workings. Employees, stationed at

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FIGURE 6. - West Portal–Mine Car and Track.

suitable intervals, manually maintained the movement of the sticks of explosives and boxes of stemming along the conveyor.

Stemming consisted of minus-1/16-inch material trucked from the mill and was transported into the workings in wooden powder-boxes and placed uncompacted in the crosscuts. The adit was stemmed to the portal (fig. 7). After the blast a considerable amount of this stemming was noted in the toe of the muckpile, 190 feet from the location of the portal.

The quarry was surveyed by Bureau of Mines personnel before and immediately after the blast. Assuming the position of the new toe from the previous slope of the blasted face and the placement of underground workings and explosives, cross sections were made through the blasted areas. Using this information, it was estimated that 209,000 tons of rock was dislodged by the 15.4 tons of explosives, the powder factor being 0.147 pound per ton of rock.

The average height of the quarry face above the west workings was 113 feet. Figures 8 and 9 show the face before and after the blast.

In the area of the east workings (fig. 10) the closer jointing of the rock, the nearby well-traveled road, powerlines, and railroad, and a low quarry face, averaging 65 feet in height, required a change in spacings of the pockets and a much lighter charge than in the west workings. A total of 3.775 tons of Tritex-W.R. and 0.575 ton of Gelamite-D was loaded in these workings (fig. 11) in the same manner as in the west workings.

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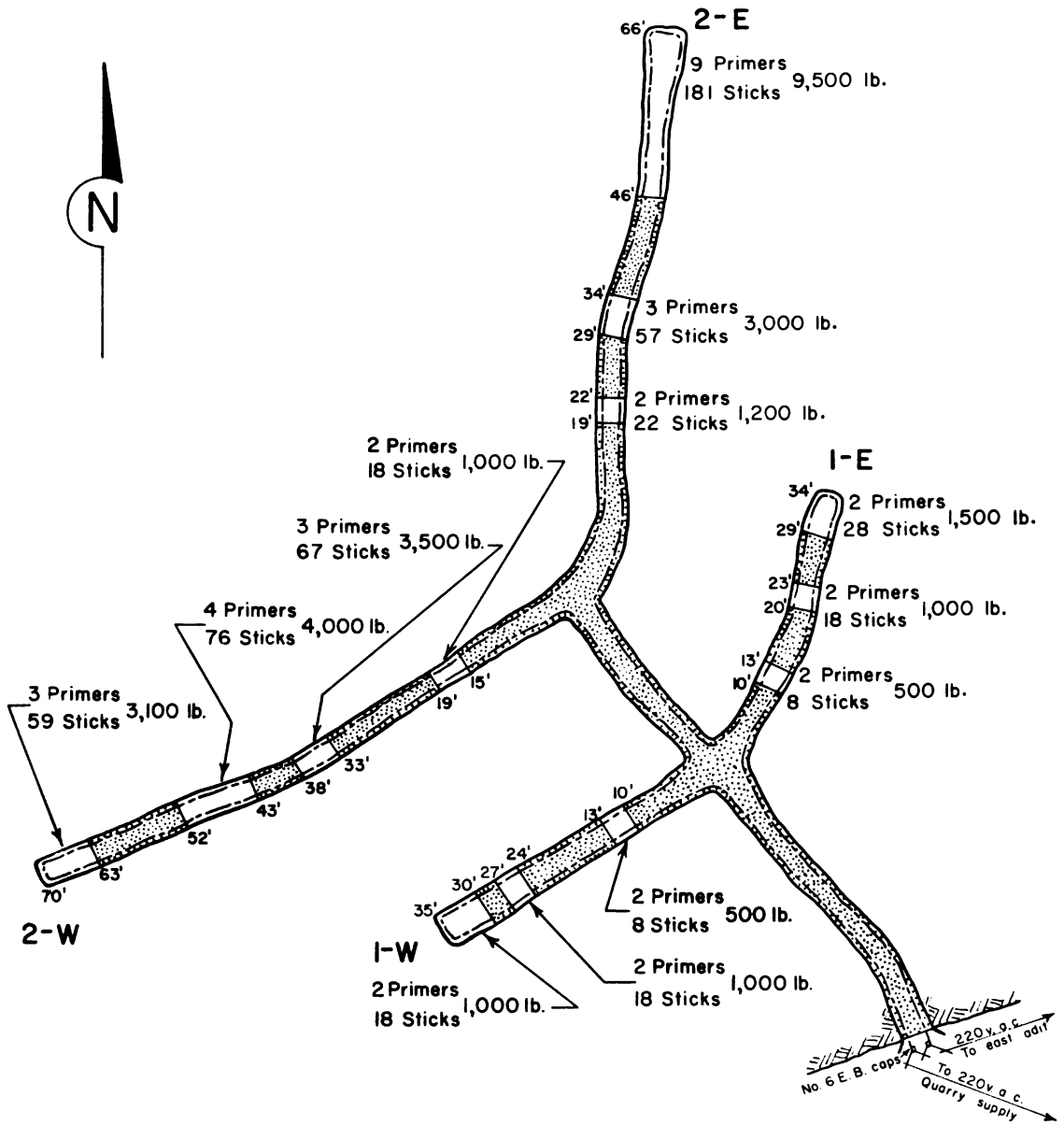

LEGEND

—·—·—	Primacord Crosstied every 10' and tied through each primer. Each connection taped.
	Stemming
	Pocket of explosives
Primers	Gelamite D, 8"x18½", 50 lb. per stick
Sticks	Hercules Tritex, WR, 8"x27½", 50 lb. per stick

FIGURE 7. - Distribution of Explosives, West Workings.

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FIGURE 8. - West Face Before Blast.

FIGURE 9. - West Face After Blast.

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FIGURE 10. - East Face Showing Jointing.

The two lines of Primacord were crosstied at the portal of each adit. A No. 6 electric blasting cap was attached to each end of the trunklines, and the caps were connected in series. The two blasts were coordinated (fig. 12) by joining a cap at each portal with a line of No. 14 wire. The remaining two caps at each portal were connected in series with the 220-volt a. c. quarry-line. The charge was detonated by closing the main blasting switch in the vicinity of the maintenance shops.

An estimated 66,000 tons of stone was dislodged in the east blast. The total amount of explosives used was 4.35 tons. The powder factor was 0.132 pound of explosive per ton of stone. Figures 13 and 14 show the face before and after the blast.

As shown in figures 9 and 14, the average size of the blasted material in the west face, ranging from pieces weighing several tons to small fragments, was much larger than the material from the east face. The spacing of the jointing played an important part in the sizing of blasted material. Very

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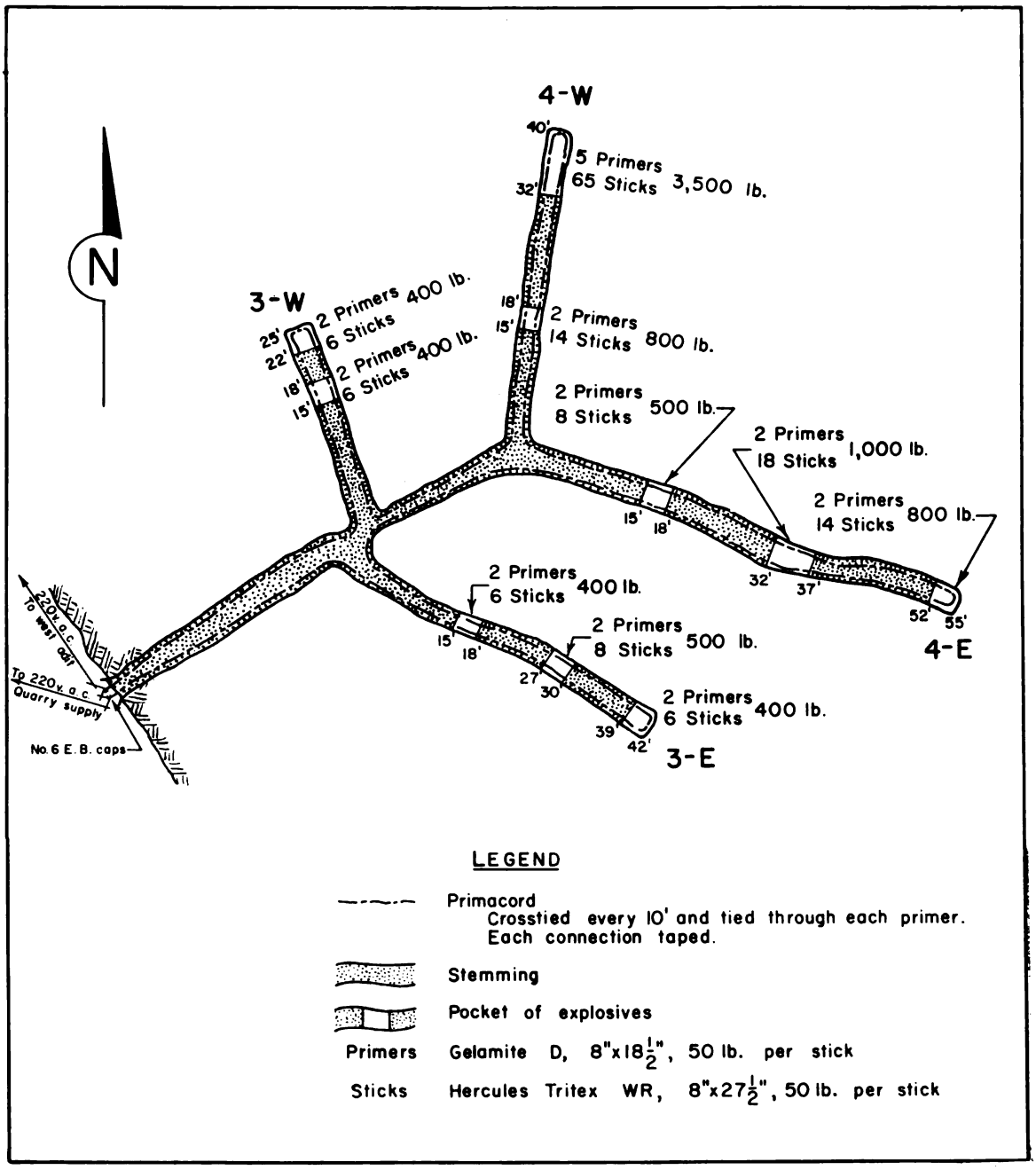

FIGURE 11. - Distribution of Explosives, East Workings.

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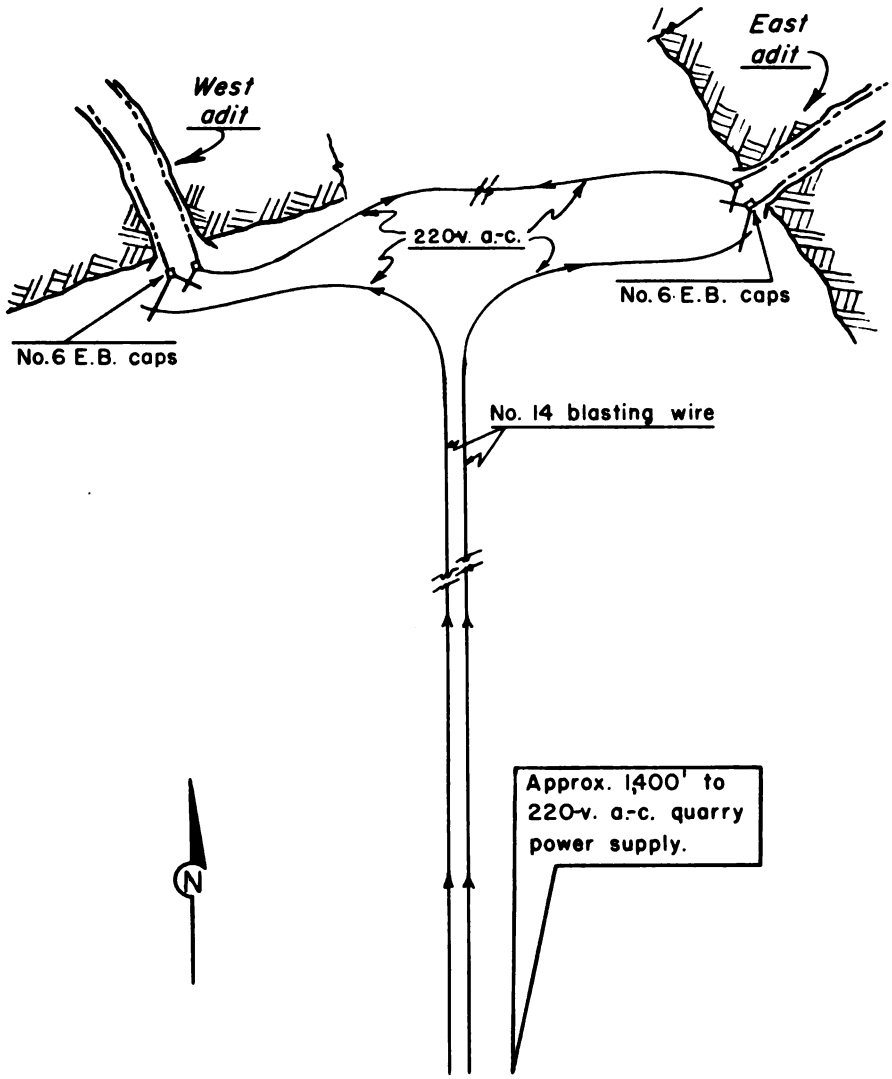

FIGURE 12. - Schematic Electric Power Supply for Blasting Operation.

little fragmentation, as a direct result of the blast, was noted. In most instances fragmentation was probably due to attrition.

Both blasts are summarized in table 1.

Secondary blasting is done mainly by mud capping, blockholing being required only on the larger rock fragments. When the shovels move into a newly blasted area, two men are assigned to secondary blasting, this number may increase to six during the final cleanup cuts.

Table 2 is a summary of operating costs in units of labor and supplies per short ton.

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FIGURE 13. - East Face Before Blast.

FIGURE 14. - East Face After Blast.

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TABLE 1. - Performance data - coyote-hole blast

Development:		
West workings	tons	390
East workings	do.	330
Total	do.	720
Explosives	lb.	2,600
Explosives	lb./ton	3.611
Drilling and blasting	man-hours	4,393.5
Loading and stemming	do.	1,259.5
Total	do.	5,653.0
Drilling and blasting	man-hours/ton	6.1
Primary blasting:		
Explosives, West blast	lb.	30,800
Explosives, East blast	lb.	8,700
Total	lb.	39,500
West blast	tons of rock	209,000
East blast	do.	66,000
Total	do.	275,000
Explosives, West blast	lb./ton	0.147
Explosives, East blast	lb./ton	.132
Total (weighted)	lb./ton	.144
Summary:		
Coyote hole development	man-hours/ton	.015
Loading and stemming	do.	.005
Total	do.	.020
Primary blasting	lb. explosives/ton	.144
Coyote hole development	lb. explosives/ton	.009
Total	lb. explosives/ton	.153

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TABLE 2. - Summary of operating costs in units of labor, power, and supplies

	Stripping	Mining
Labor (man-hours per short ton of stone):		
Drilling and blasting (coyote hole)		0.02
Blasting, secondary		.03
Loading	0.01	.05
Haulage	.01	.04
Miscellaneous		.02
Supervision		.01
Total labor		.17
Labor (percent of total cost)		52
Average tons per man per shift		71
Power and supplies:		
Explosives, secondary blasting, lb./ton		0.033
Explosives, primary blasting, do.		.153
Total, do.		.186
Fuel (coal):		
Shovels, tons		.005
Locomotives, do.		.009
Total fuel, do.		.014
Other supplies (in percent of total supplies)		60
Supplies (percent of total cost)		30
Percent of total cost		82
Unclassified costs (percent of total cost)		18
Total		100

LOADING AND HAULING

Loading is done with two 120-ton Marion-Osgood steam shovels (fig. 15) equipped with 4-1/2-cubic-yard Eimco-Mesabi buckets. These two shovels will load from 1,300 to 1,500 tons per shift.

The stone is loaded into 12 Petlar and 18 Kiburn-Jacobson 10-ton-capacity, side-dump cars (fig. 16). Three 35-ton Porter steam locomotives (fig. 17) haul the stone to the crushing and screening plant in 6-car trains on standard gage track. One 25-ton Porter locomotive is used for switching cars at the crushing plant. The average haul to the mill is 0.65 mile; the last 1,500 feet has a plus-1.46 percent grade. The stone is dumped directly into an Allis-Chalmers 72- by 84-inch jaw crusher, driven by a 650-hp. d. c. motor. The crushing and screening plant produces 14 sizes of stone, 8 at any one time. Processed stone ranges in size from 4-1/2 inches to minus-1/16-inch, with the major production being 1-1/2 inches and less. Figure 18 is a general view of the mill.

Mainline tracks of the Minneapolis, St. Paul, and Sault Ste. Marie Railroad adjoin the mill and quarrysite. The railroad company maintains about 2 miles of track on the mining company's property.

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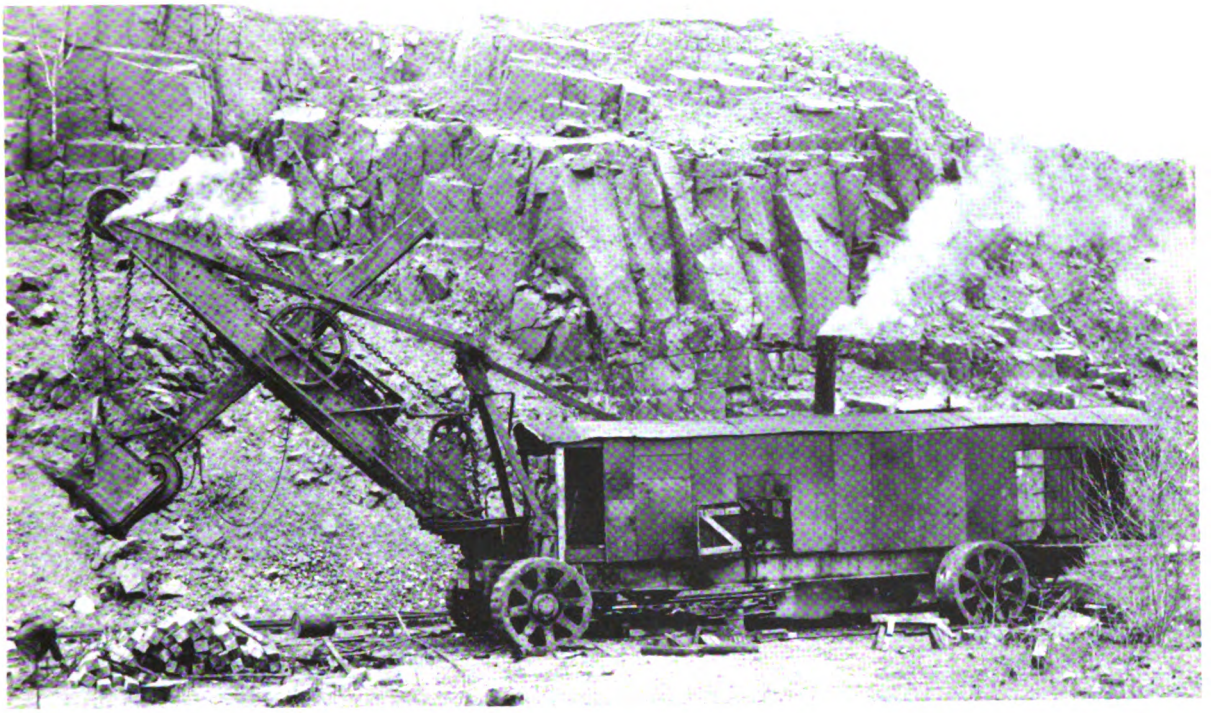

FIGURE 15. - Marion-Osgood Steam Shovel.

FIGURE 16. - Side-Dump Quarry Cars.

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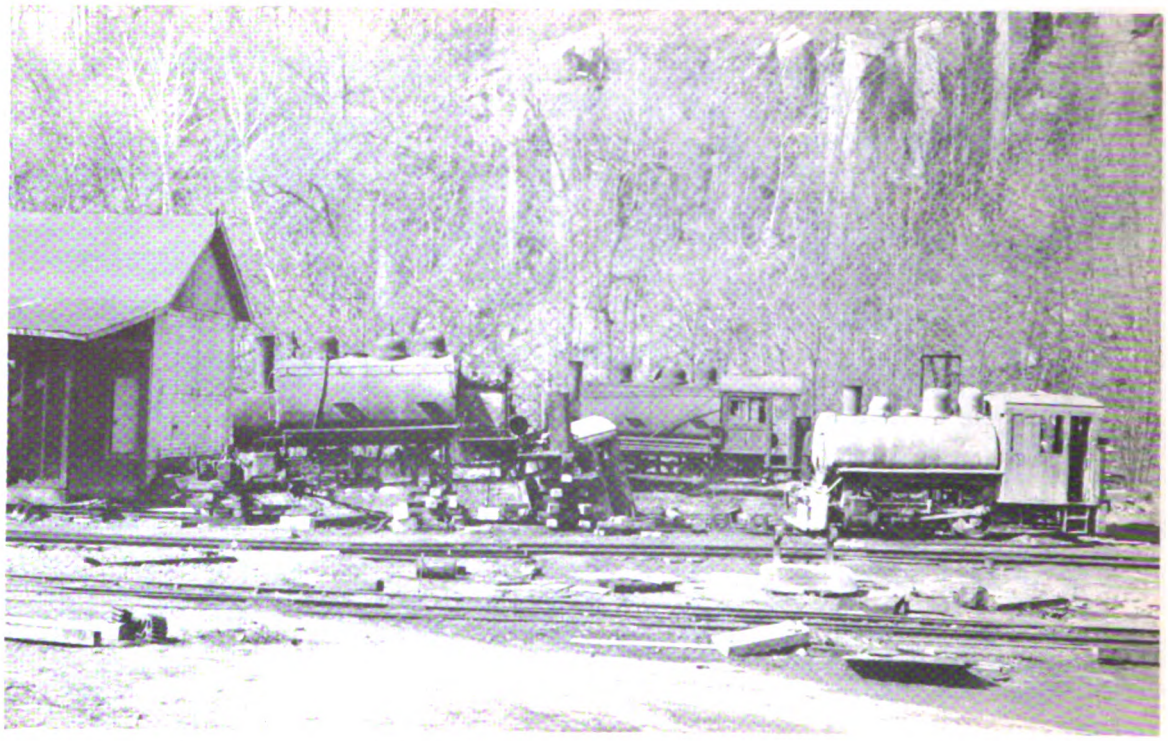

FIGURE 17. - Haulage Locomotive.

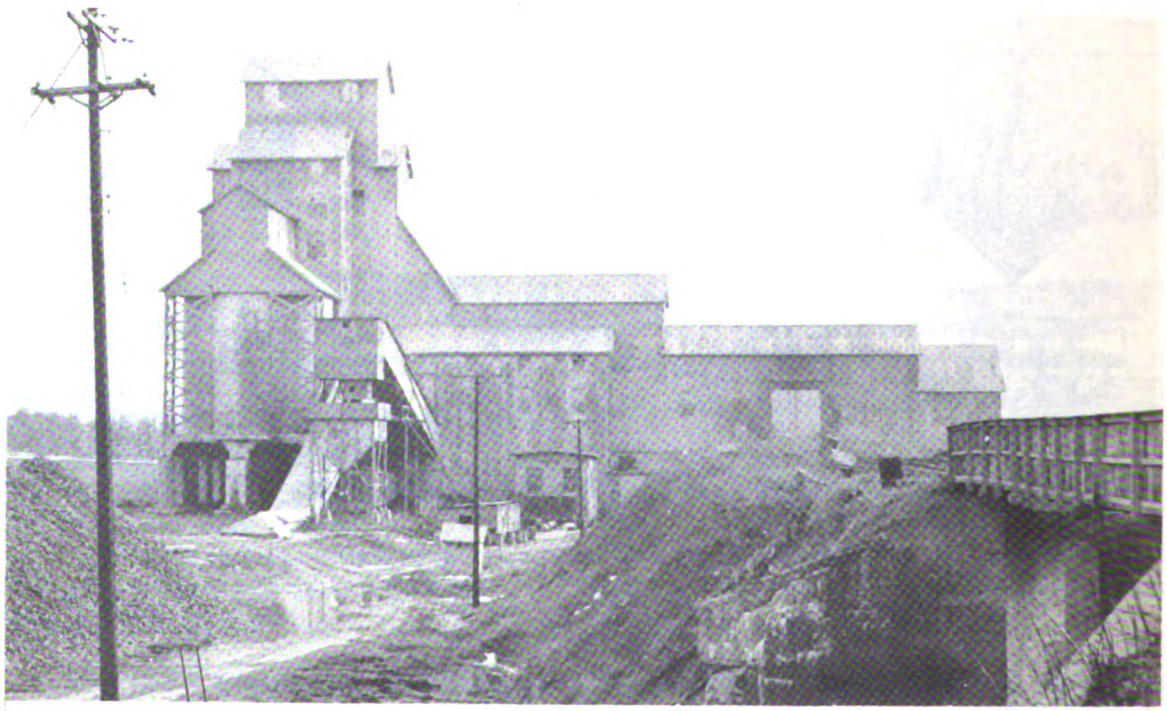

FIGURE 18. - The Mill.

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